

**Draft Plan for Research in  
Environment**

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## PIER ENVIRONMENTAL RESEARCH

### I. Electricity Generation and Environmental Impact

#### A. Contribution of Electricity Generation to Air Emissions

The main air pollutant emitted from power plant stacks is NO<sub>x</sub> (nitrogen oxides). NO<sub>x</sub> is a precursor for both ozone and particulate matter (PM), for which both state and federal ambient air quality standards have been established. Consequently, this discussion primarily focuses on NO<sub>x</sub>.

On an annual statewide basis, the contribution of NO<sub>x</sub> emissions from the electricity generating sector to the total is quite small, on the order of 3.5 percent. However, if we compare emissions at different regional and temporal aggregation levels, it is clear that the electricity generation is still a significant contributor to NO<sub>x</sub> emissions. For example, the following table indicates that at the county level, NO<sub>x</sub> emissions from power plants can contribute an amount equal to as much as 50 percent of the total contribution from on-road vehicles, which is considered to be the main source of NO<sub>x</sub> emissions in California.

**Comparison of 1996 Estimated Annual NO<sub>x</sub> Emissions**

Region	Electricity Generation (thousand tons per year)	On-Road Vehicles (thousand tons per year)	Ratio Gen. Vs Vehicle %
Contra Costa County	4.38	16.43	27
San Francisco County	1.46	7.30	20
Monterey County	4.02	8.03	50
Kern County	6.20	18.98	33
Sutter County	0.36*	1.83	20
South Coast Air Basin	6.2	255.50	2
Source: Air Resources Board ( <a href="http://www.arb.gov">http://www.arb.gov</a> )			
* Emissions may be overstated due to rounding rule used to report the original data			

From a temporal perspective, the relative contribution of power plant emissions during high ozone episodes are significantly higher than what is shown in the table above. This is

because high ozone episodes are also characterized by high ambient temperatures that generally result in a significant increase in electricity use.

Future emissions from the generating sector are expected to decrease due to the implementation of emission control retrofit rules for existing power plants and the displacement of old facilities with more efficient new or re-powered power plants. However, at the same time, NO<sub>x</sub> emissions from all sources, including on-road vehicles, are also expected to decrease significantly, as existing rules and new rules enter into full effect.

### **Unique features of Power Plant Plumes**

Power plant plumes have unique features that influence their physical behavior and chemistry. Power plant plumes are highly buoyant with relatively high NO<sub>x</sub> concentrations. For this reason, in general, these plumes rise well above the height of their stacks. The effective plume height may reach 200 meters or more, depending on the atmospheric conditions. This facilitates the transport of pollutants over long distances and, in some cases, to regions that would not be expected to be affected from just looking at conventional surface level meteorological data.

Relatively high NO<sub>x</sub> concentrations with respect to background levels result in different chemistry inside the plume than outside it. NO<sub>x</sub> rich plumes, for example, results in a reduction of ambient ozone concentrations near the power plant, while ozone concentrations far from the source may increase. The NO<sub>x</sub> plume may also result in a more rapid production of nitric acid and, perhaps, a more efficient production of secondary particulate matter. Current photochemical models do not represent power plant plumes adequately.

### **Air Quality Studies**

Air quality agencies, electric utilities, and other groups have been sponsoring collaborative air quality studies in California to gain a better scientific understanding of the causes of air pollution and the chemical and physical processes included in secondary pollutant formation. This information is needed to design technically sound air quality management plans (AQMPs) for attaining or maintaining ambient air quality standards. Despite the previous research in this area, significant knowledge gaps still remain. This fact has been further exacerbated by the recent adoption by the U.S. EPA of two new, more stringent, ambient air quality standards: an 8-hour average ozone standard, and a 24-hour average standard for particulate matter of less than 2.5 microns of size (PM<sub>2.5</sub>). Violations of these new standards are found even in areas with few, if any, significant sources of pollution. Therefore, long range transport of pollution is now a more pressing problem than before and, as suggested above, power plant emissions may play an important role in regional pollutant transport.

There are multiple areas of research that need urgent attention in order to better understand and resolve regional air pollution problem. For example, a better characterization of winds aloft is needed to understand how pollutants are accumulated and transported aloft and fumigated to

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ground level the following day. Transport aloft has been found to contribute, in some cases, about 40 percent or more of the measured maximum ozone concentrations in some areas. In addition, mixing and transport aloft may also be a very important source of secondary PM formation during the wintertime, when the highest PM concentrations are measured in California.

### **Importance of Air Quality Management Plans (AQMPs)**

The end result of an air quality study is to provide better tools for the development of air quality attainment strategies as they pertain to mobile, area, and stationary sources, including power plants. These strategies delineate the future level of controls needed for existing power plants as part of the general compliance strategy for the air basin as a whole.

Historically, power plants in California have been heavily affected by AQMPs. For example, the almost absolute reliance on natural gas in the major air basins in California is the result of regulatory constraints on the use of other fuels, which was deemed necessary and cost effective in order to reduce ambient air pollutant levels.

The mitigation of ozone and secondary particulate matter impacts from proposed new power plants in California is, at least in part, due to the presence of an overall air regulatory agency strategy to reduce ambient ozone and PM concentrations. The non-linear nature of ozone and the PM formation requires comprehensive approaches to make sure that the overall reductions of pollutants will actually result in improved air quality. An example of this non-linear behavior is the recently observed increase of ozone concentrations on weekends in certain air basins in California. This is surprising since emissions levels are expected to decrease significantly, but in different proportions, during weekends.

The results of air quality studies could also be used to develop sound inter-basin, inter-sectoral offset strategies. This would allow, for example, the siting of new power plants in areas with few, if any, significant industrial sources of emissions but that are heavily impacted by an upwind air basin. In this situation, the siting of new power plants is difficult because of the lack of sources of offsets in the area where the power plant would be located. Some new proposed power plants are considering inter-basin offsets as one strategy to obtain necessary permits. However, this strategy may be limited by the current lack of qualitative understanding of inter-basin transport processes.

### **B. Water**

To be completed

### **C. Biological Resources**

To be Completed

## **D. Land Use**

To be completed

## **II. Research Goals**

By 2020, new energy facilities, by using improved designs, should not have any direct significant impact on the water or air environment or impose any significant hazard to the public. New energy facilities will minimize or avoid any direct significant impact on biological resources and/or land uses. The total, aggregated impact from existing power plants and other energy facilities, including those built through 2020, should be eliminated, reduced, or mitigated to 50 percent of 1990 levels.

## **III. Research Issues**

**Issue 1:** Research is needed to provide solutions which reduce or eliminate the air quality, land use, biological and water related impacts of electricity generation, distribution and use in California.

### **Air Quality**

1. There is an inadequate scientific understanding of ozone and particulate matter formation, transport, and accumulation as it relates to electricity generation.
2. Models for non-reactive pollutant prediction are unreliable and difficult to apply to proposed electricity generation.
3. Characterization of reactive organic compound and particulate matter emissions from power plants does not exist and/or needs improvement.
4. There is an inadequate understanding of the role and relationship of outdoor and indoor generated air pollution and its relationship to childhood asthma. Outdoor air is introduced indoors as ventilation air in amounts established by the Commission's building ventilation standards and all pollutants accumulate indoors.
5. There is an inadequate understanding of the role of air pollution and incidences of cancer since outdoor air, introduced indoors, dilutes indoor-generated pollutants in energy efficient buildings.
6. Inadequate ventilation in school buildings, which have been made more airtight to conserve building energy, appears to be related to an increase in childhood illness.

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## **Water**

1. It is currently difficult to determine the role of atmospheric deposition of pollutants from energy production and consumption in water quality degradation.
2. There is a need to develop new methodological and technological approaches to evaluate and reduce cooling water intake structure impacts to fish and other aquatic life.
3. There is a need to develop alternative water sources and alternative technologies/methods of treatment of these alternative water sources for electricity generation.
4. The negative effects of thermal power plants on aquatic resources in freshwater and marine environments need to be reduced.

## **Land Use and Biological Impacts**

1. Bird collisions with power lines have been documented for decades, however the extent or seriousness of this issue is poorly understood.
2. Large perching birds (mostly raptors) are electrocuted on electric distribution lines throughout California. The severity of the problem is not well understood.
3. Numerous birds, including some protected species, are killed or injured when they collide with wind turbines. California's wind resource areas are being repowered with large, more efficient turbines. It is not known whether these new large turbines represent a greater, lesser or the same threat to birds.
4. It is not well understood how best to manage watersheds which contain hydroelectric development.
5. It is not well understood how best to manage transmission and distribution line right-of-ways in a manner that will lessen the likelihood of vegetation-related fires and associated power outages, and increases their habitat values.

**Issue 2:** Research is needed to understand the nature and significance of global climate change, its relationship to electricity generation and use, and to develop strategies and solutions that respond to any identified impacts.

1. The difficulty in accurately estimating GCC emissions (CH<sub>4</sub>, N<sub>2</sub>O, and SF<sub>6</sub>) may mislead future GCC policies to the detriment of energy use in California.
2. Potential regional impacts from global climate change are currently unknown.
3. Efforts to reduce greenhouse gas emissions need to be integrated with Air Quality Management Plans to avoid contradictory policies and inefficiencies.

**Issue 3:** Research opportunities should be provided which allow the innovation of the market to provide solutions to environmental issues.

1. Important environmental research opportunities may present themselves during the course of the PIER program. A placeholder should be reserved to allow for research opportunities that develop solutions in response to these opportunities.

## IV. Research Plan

### A. PIER Environmental Research Currently Initiated

#### *PIER Transition Projects*

1. Regional Ambient Aerosol	PG&E	\$399K
2. Bird Strike Monitor	PG&E	\$100K
3. Avian Powerline Interaction Committee	PG&E	\$40K
4. Food Services Technology Center	PG&E	\$500K
5. Wildlife Interactions w/ Energy Facilities	PG&E	\$130K
6. NO <sub>x</sub> Formation in Industrial Gas Burners	CIEE	\$335K
7. Trenchless Burial Equipment	SDG&E	\$130K
8. UV Printing on Plastics	SCE	\$250K
9. Habitat & Species Protection	SCE	\$525K
10. Desert & Mountain Air Transport	SCE	<u>\$825K</u>
<b>Total</b>		<b>\$3.2M</b>

#### **PIER 1 Contracts**

1. Global Climate Change	EPRI	\$2.1M
2. Golden Eagles in a Perilous Environment	U.C. Santa Cruz	\$675K
3. Potable Water Production/Env. Protection	Edison Tech.	<u>\$2.9M</u>

**Total** **\$5.7M**

**Total Current Research Contracts:** **\$8.9M**

## **B. 1999 Environmental Research Initiatives**

The following projects are proposed for initiation by the PIER Environmental team during calendar year 1999. It is not anticipated that all the funds needed to complete each project come from either FY 98/99 or FY 99/00 PIER funding. Funding for multi-year projects will come from PIER funds allocated to the Commission during Fiscal Year the work is actually completed.

### **Water**

#### **1. Technologies for the efficient use of degraded water for power plant cooling.**

This project will establish a collaborative with water agencies and power plant equipment manufacturers to:

- Test the physical components of degraded water supplies that are already available in California and potentially usable for power plant cooling
- Identify the barriers to their use.
- Identify potential technologies that can overcome these barriers.
- Initiate testing and/or development of the most promising technologies.

Project Start:	Establish Collaborative	First Quarter 1999
	Fund Collaborative Research	Fourth Quarter 1999

Term:	Establish Collaborative	One Year
	Fund Collaborative Research	Two Years

#### **2. Dry Cooling Technologies**

This project will:

- Examine the barriers to the use of dry cooling technologies which completely or substantially eliminate the use of water for power plant cooling.
- Develop and initiate testing of technologies to overcome these barriers.

Project Start: First Quarter 1999

Term: One Year

Anticipated Research Method: Tailored Collaborative

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### **3. Reduce impacts of cooling water intake and discharge on aquatic habitat.**

This project will:

- Examines existing power plants using once-through cooling and their impact on the marine environment.
- Recommend methods and technologies to reduce the identified impacts.

Schedule: First Quarter 1999

Term: Three Years

Anticipated Research Method: Tailored Collaborative

**Total New Water Related Research: \$2.8 Million**

#### **Air Quality**

### **1. Central Valley Ozone Transport Study**

This project contributes toward the completion of the California Air Resources Board studies on the impacts of ozone transport in California's central valley and modify those studies for direct application to power plants. The portion of the study funded by PIER will be proportional to the impacts related to the electricity sector.

Project Start: First Quarter 1999

Term: Four Years

Anticipated Research Method: Interagency Agreement

### **2. Long Range NO<sub>x</sub> Transport Study**

This project will gather 3-D data on wind fields and refine air quality models to allow the accurate estimation of power plant plume transport. This project will address the unique nature of power plant plume movement and chemistry.

Project Start: First Quarter 1999

Term: Three Years

Anticipated Research Method: Interagency Agreement and/or Tailored Collaborative

**Total New Air Related Research:**

**\$ 3.5 Million**

## **Biological Resources and Land Use**

### **1. Watershed Management**

This project will complete on-going studies designed to develop a better understanding and more environmentally sensitive management methods for watersheds containing hydroelectric power plants.

Project Start: First Quarter 1999

Term: Three Years

Anticipated Research Method: Tailored Collaborative

### **2. Transmission right-of-way management**

This project will develop improved management methods for transmission and distribution right-of-ways that reduce the likelihood of vegetation-related fires and associated power outages and increase the wildlife habitat value of the right-of-way.

Project Start: Second Quarter 1999

Term: Two Years

Anticipated Research Method: Interagency Agreement

**Total New Biological and Land Use Research:**

**\$1 Million**

## **Global Climate Change**

### **1. Improve the estimation of greenhouse gas emissions from California sources.**

Research is needed to determine the accuracy of current estimates of greenhouse gas emissions in California. Without accurate information, decision-makers will not have the information needed to develop policies related to global climate change and the appropriate response from California business and government.

Project Start: Third Quarter 1999

Term: Three Years

Anticipated Research Method: Interagency Agreement and/or Tailored Collaborative

**Total New Global Climate Change Research:                      \$2 Million**

## **Environmental Electrotechnologies**

- 1. Determine the potential net environmental benefits of environmentally related electrotechnologies in California and provide technical assistance to begin development.**

Environmentally related electrotechnologies have the potential to provide significant net environmental benefits to Californians. These projects will:

- Assess the feasibility and net environmental benefits of these technologies.
- Identify promising research.
- Identify the appropriate research pathway/strategy.
- Provide for the initial technical development of the most promising technologies.

### **Feasibility Study**

Project Start: First Quarter 1999

Term: One Year

Anticipated Research Method: Technical Support Contract

### **Technology Development**

Project Start: Fourth Quarter 1999

Term: Two Years

Anticipated Research Method: To Be Determined By Feasibility Study

**Total New Electrotechnologies Research: \$1.8 Million**

## **Technological Innovation**

- 1. Provide opportunities for innovative environmental research.**

This project will provide funds to the PIER Small Innovator Program to offer opportunities for energy-related environmental research that advances the understanding of innovative solutions to current and future problems.

Project Start: Based on PIER Small Innovator Program schedule

Term: Based on PIER Small Innovator Proposals

**Total New Technological Innovation: \$2 Million**

**Total New Environmental Research Initiatives: \$13.13 Million**

## **V. Research Organizations and Persons Consulted**

### **Air Quality**

**Andy Ranzieri, CARB**

**Prof. Akula Venkatram, U. C. Riverside**

**Prof. Robert Harley, U. C. Berkeley**

**Dr. Christian Seigner, CARB**

**Dr. Peter Mueller, EPRI**

**Prof. Glen Cass, California Institute of Technology**

**Prof. John Watson, Desert Research Institute**

### **Biological Resources/Habitat**

**Jim Young, Southern California Edison**

**Dan Pearson, Southern California Edison**

**Donna Lindquist, Plumas Corporation**

**Jim Davis, EPRI**

**Winston Chow, EPRI**

**Don Porcella, EPRI**

**Sheila Byrne, PG&E**

**Mark Dedon, PG&E**

**Mike Morrison, NREL**

**Steve Railsback, Lang, Railsback & Associated**

**Jim Cole, CIEE**

**Truman Young, UC Davis, Dept. of Environmental Horticulture**

### **Global Climate Change**

**Dr. Florentin Krause, LBL and IPSEP**

**Prof. Stephen DeCanio, UC Santa Barbara, Dept. of Economics**

**Prof. Robert Wilkinson, UC Santa Barbara**

**Dr. Mark Levine, LBNL**

**Prof. Stephen Schneider, Stanford Univ., Dept. of Biological Sciences**



**Dr. Peter Gleick**, Pacific Institute for Studies  
**Chuck Hakkarinen**, EPRI  
**Dr. Tom Wilson**, EPRI

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## **Public Health**

**Dr. Jed Waldman**, California Dept. of Health Services

**Peggy Jenkins and Tom Phillips**, CARB

**Barbara Spark**, U. S. EPA - Region IX

**Joan Daisy**, LBL

## **Water Resources**

**Jim Green**, Metropolitan Water District

**Deborah Nagle**, Environmental Protection Agency

**Bob Brockson**, EPRI

**Kent Zammit**, EPRI

**Bob Goldstein**, EPRI

**Chuck Hakkarinen**, EPRI

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